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ABSTRACT

This brief report describes an exploratory pilot project in which sixth-grade students used hand-held calculators throughout the school year. The report includes guidelines on the purchase and use of calculators as well as advice on gaining community support for such a project. Issues related to classroom management are discussed; in particular, the desirability of providing students with their own calculators is explained. Six areas of mathematics in which the calculators were particularly useful are described, and sample problems from each are provided. These areas are: word problems, arithmetic mean, probability, adding to produce palindromes, functions, and decimals. In conclusion, the authors observe that pupils were interested throughout the year and that they accepted the calculator as a tool which allowed them to be more independent and proficient in mathematics. (SD)

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USING HAND-HELD CALCULATORS IN SIXTH GRADE CLASSES

a brief report of an educational project

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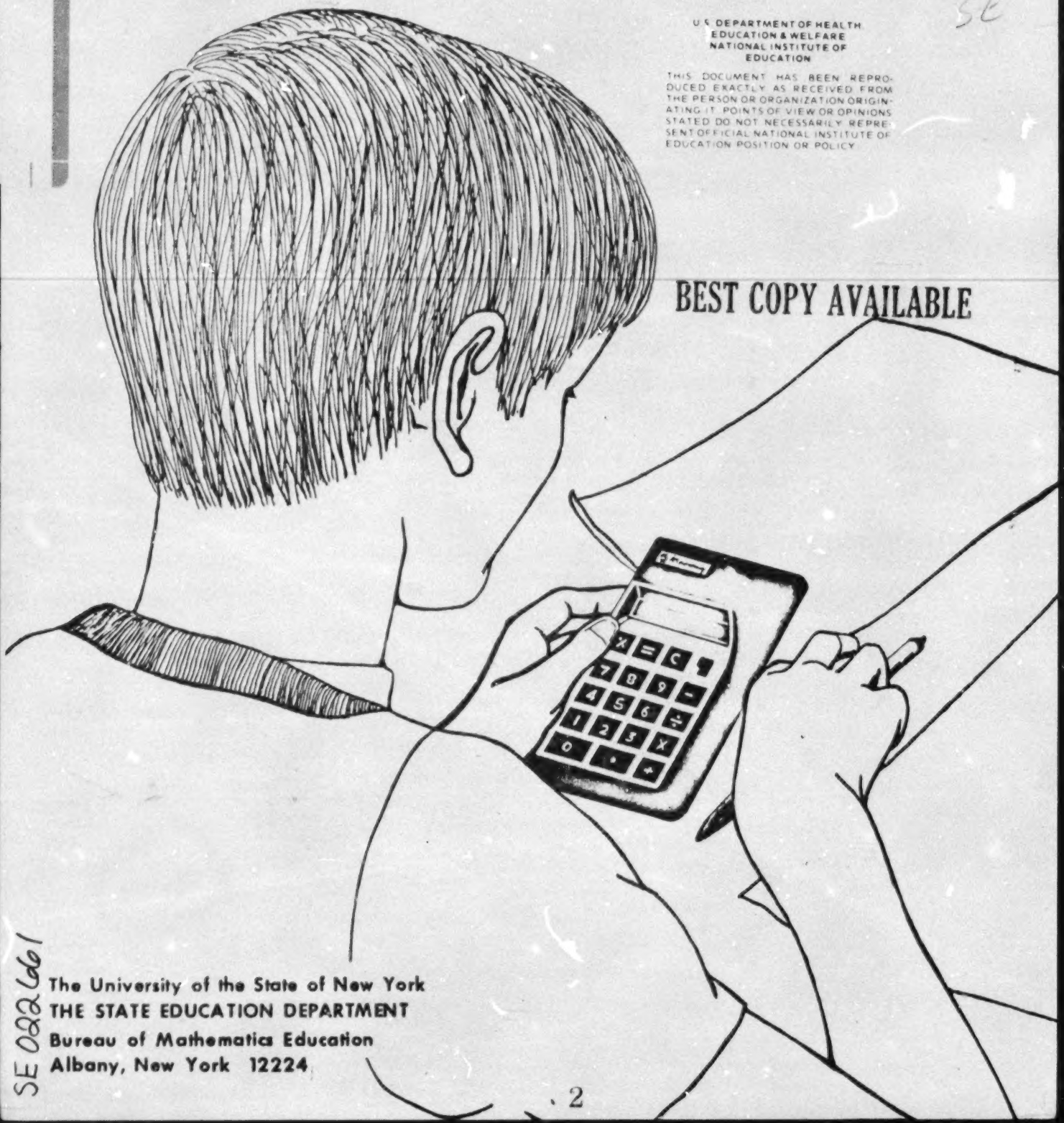

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TABLE OF CONTENTS

	Page
INTRODUCTION.	2
GOALS AND GUIDELINES.	2
CLASSROOM ORGANIZATION.	3
AVAILABILITY OF CALCULATORS	3
MAINTENANCE OF INTEREST	3
SOME INTERESTING MATHEMATICAL TOPICS.	4
DEPENDABILITY OF CALCULATORS.	6
CONCLUSION.	7

This report was written by two sixth grade teachers who conducted classroom trials of hand-held calculators:

Ray Barrett, Citizen Genet Middle School, East Greenbush, N.Y.
Michael Keefe, Colonie Village School, Colonie, N.Y.

In September 1973 each student in a sixth grade class in each of the two schools was provided with a hand-held calculator to use during mathematics lessons for an entire school year

Tom Bennett, principal of Citizen Genet School, and Paul Daby, principal of Colonie Village School, supervised the trials at the schools. Frank Hawthorne and John Sullivan of the Bureau of Mathematics Education, New York State Education Department, directed the project.

The calculators were provided, free-of-charge, by Bowmar/A.L.I., Inc. At the completion of the trials the calculators were donated to the schools.

INTRODUCTION

The project was organized by the New York State Education Department. Two schools, one in East Greenbush, the other in South Colonie, were chosen to participate in the project.

A sixth grade of twenty-eight to thirty pupils was selected in each district. Each child was provided with a calculator for use during math lessons for the entire year. No specific outcomes were designated for this pilot project. It was exploratory.

GUIDELINES

Students learned quickly how to use the calculators to add, substract, multiply, and divide. The booklet accompanying each calculator proved very helpful. The teachers prepared large bulletin board mock-ups of the keyboard and screen to help them explain calculator functions. However, the discovery method is probably the best one for the child to use in becoming familiar with a calculator.

To increase chances for success, it was felt that the cooperation of the Board of Education and community was needed. After considerable discussion the Boards of Education approved participation in the project.

Board approval was followed by a letter to the parents explaining the project and requesting permission for participation by the children. An informational meeting for parents and children was helpful.

Those in charge of this project received many questions from parents, educators, and newsmen expressing concern that the use of calculators would substitute for, and eventually replace understanding of mathematical concepts, and development of basic computational skills. It was feared that children would become dependent on calculators - helpless to do ordinary arithmetic without them. We do not know if this is likely to happen but in this project we were determined to use the calculator to help develop understanding of mathematical concepts and basic computational skills. Positive direction insured that children would not become dependent on the calculators.

The whole question of care and maintenance of the calculators, though vital, is variable with the make and model, and the school facilities. In our project, for reasons no one completely understands, one of the classes using calculators had very few breakdowns. The other class had a rather large number of calculator malfunctions, particularly the loss of battery charge after a short period of use.

When purchasing calculators schools should make clear agreements with suppliers about replacements. A system should be set up in advance so that when breakdown occurs, the company will immediately supply a replacement.

Care should be taken to insure that calculators do not offer undue advantage to one group of students over another. Ordinarily they should not be used on tests.

Orientation for teachers should be an integral part of any educational project. Teachers actually instructing pupils in the program should be competent in the operation of the calculator. This presents no difficulty. Other teachers coming into contact with pupils using calculators should have a basic knowledge of the project and the use of the calculator. This tends to prevent misunderstandings. The actual use of the calculator can be learned in less than one-half hour using the accompanying instruction booklet.

CLASSROOM ORGANIZATION

Each calculator must be easily and quickly identified by its student "owner." Self-adhering tags were used in one class with large numbers printed on the outside. This matched a small plastic tape number on the back of each calculator.

A facility must be available for storage and recharging of the calculators and it must be locked securely when not in use by students. Both in-class and hallway facilities were tried and it was decidedly more practical having the recharging closets inside the classroom. Small units of six sockets with a switch operating each unit seemed very practical.

It should be evident from the above that the organization and use of classroom facilities and equipment becomes a most important part of orientation of the pupils before and during the project. Discussion of the frailties of miniaturized electronic equipment should lead to rules of behavior which can be enumerated by pupils under the guidance of the classroom teacher.

AVAILABILITY OF CALCULATORS

It is recognized that not every pupil will be using a calculator every day. However, it is beneficial for each student to have the responsibility for the care of one calculator which will be available for his or her use during math periods. In support of this we mention the following:

1. Introduction to the calculators and some phases of the curriculum may be more efficiently taught if each child has a calculator.

2. If pupils must share a calculator, a dominant pupil may use it while a shy one watches, not gaining full benefit of actual contact with the machine.

3. Children seem to respond positively to the responsibility of having a calculator in their charge.

MAINTENANCE OF INTEREST

Pupil interest may be kept at a high level in many ways. Items of current interest taken from newspapers or local school happenings can be used, many related to

several subject matter areas. It is helpful to set aside a day occasionally (perhaps two consecutive days) when no one may use calculators. Most important, the calculators permit in-depth exploration of many mathematical topics which are inherently interesting but which require computation.

The key word for maintaining interest in the calculators is "availability." The calculators should be available to the students except when they would interfere with the objectives of the lesson. The teacher should take care not to "force" the children to use the calculator. This can create resentment and boredom on the part of the student. Let the lesson itself require use of calculators. For example, when teaching about prime numbers few teachers would ask children to determine if 7631 is a prime number. With calculators available the exercise is feasible.

There has to be a happy balance between teacher-initiated and pupil-initiated activities.

SOME INTERESTING MATHEMATICAL TOPICS

Certain topics were particularly enjoyable, and are discussed here as samples of the kinds of things that can be done using calculators.

1. Word Problems

Word problems provide an excellent opportunity for using calculators creatively. Problems given orally prove interesting. For example, one might ask, "How long ago did Columbus discover America?" or, "In how many years will it be the year 3286?" Word problems with negative numbers can also be introduced. For example, "If a football player lost 6 yds., on one play, gained 12 yds. on the next play, and on the last play lost 20 yds., how many yards did he lose in all?"

These are just two examples of the hundreds of word problems one can devise. Incidentally, the children can also have fun making these up and giving them to each other to solve.

The calculator is especially suited for verbal problems because the hardest part of a word problem is knowing what operation to use, not the actual computation. Thus, the progress of the lesson is not slowed by computational activity.

2. Arithmetic Mean

The calculator is well-suited to this. The children can keep track of their own averages and construct line or bar graphs showing their progress. Averages appear in many of society's activities (sports, business) and this imparts special interest.

3. Probability (World Series Time and Arithmetic)

Early October provided a fine time to introduce decimal fractions, percentage, and probability, through reference to the World Series.

First, the children were shown how league standings are determined. Divide the number of games won by the total number of games to determine each team's winning "percent."

Second, a table showing "World Series Games Won" was provided covering the period 1905-1972. This table permitted investigation of such questions as "How many times was the Series won in 5 games?" "What are the chances that the Series will last 7 games?" "What percent of the times did the winning team win the 1st game?"

The World Series and the calculator provided excellent opportunities to get the children interested in percent. The calculators, of course, strongly motivate the use of decimal fractions.

4. Adding To Produce Palindromes*

Palindromes provide an interesting topic especially when calculators are available. It was fun to start with any two digit number, not itself a palindrome, such as 52. Reverse the digits and add to the original number.

Thus,
$$\begin{array}{r} 52 \\ +\ 25 \\ \hline 77 \end{array}$$
results in a palindrome.

Some numbers do not produce a palindrome in the first two or three steps. For example, 96 takes four steps.

$$\begin{array}{r} 96 \\ +\ 69 \\ \hline 165 \\ +\ 561 \\ \hline 726 \\ +\ 627 \\ \hline 1353 \\ +\ 3531 \\ \hline 4884 \end{array}$$

The calculator did the addition for the children and this kept their interest, especially the numbers that took many steps to produce a palindrome. This proved to be an excellent enrichment topic. This kind of activity is a boon to weak students. With the calculator they can keep up with other students to some extent.

5. Functions

This can prove to be an interesting topic with a calculator. Given a sequence of numbers, you can experiment with the calculator in order to find the function rule and the next number. The children enjoy this because they can make up their own functions and give them to other students to try and figure out. [Ex., What is the next number in the sequence 2, 5, 11, 23...?]

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* A palindrome is a numeral whose digits are in the same order backwards or forwards, such as 66, 191, 3223, 45654.

6. Decimals

One class did good work with decimal fractions following this format: Work the following multiplication examples. Make sure that you put a decimal point in each answer.

$5.76	$12.98	2.47	3.25
x 22	x 121	x 3	x 15

Check each of the examples above with your calculator. Be sure that the decimal point in the answer is in the correct place (it should agree with the calculator). After you have checked each example above and agreed on the solution offered by the calculator, work the examples below. Most of the examples below have decimal points in both factors. Make sure that your placement of the decimal point in each answer agrees with the calculator. As you work the examples see if you can form a rule for placing the decimal point in the answers of examples like these.

2.14	30.5	2.47	3.25	7.44
x .7	x .3	x .3	x 1.5	x 4.6

The above topic was treated as a project in exploration and discovery of a rule for placement of the decimal point in the answer of problems involving multiplication with decimal fractions. The first child to discover the rule (about 17 minutes) was very excited and most others followed suit in 18 to 23 minutes. Similar success was experienced in seeking rules for divisibility. (How can we tell when a number has 3 as a factor?)

DEPENDABILITY OF CALCULATORS

The calculators seemed quite sturdy. Even when dropped from desk tops they showed no damage.

Incidence of calculator failure was significant, and some calculators would begin showing the "L" warning light after an hour of use. (This indicates a need for re-charging.) The main problem was not being able to hold a charge for a suitable length of time.

There is no way to tell how nearly discharged the calculators are until a built-in signal appears to tell you that the unit will no longer perform reliably. Due to differences in brands of calculators it is recommended that the manufacturer's recharging suggestions be followed carefully. Fortunately all pupils do not use the calculators the same amount of time each day so the recharging is staggered and pupils borrow others while their's recharges for five to seven hours.

The readout screens are protected by clear plastic so care must be exercised in wiping away dust or fingerprints so that scratches will not blur the digits. It is important to select a calculator whose display numerals are large, clear, and easily read.

CONCLUSION

Calculators seemed to promote and encourage study of mathematics. However, it would be foolhardy to expect improved mathematics achievement because of use of calculators. There were many factors involved beside calculators.

What can be said is that the pupils' interest was sustained during the year and that they accepted the calculator as a tool to help them become more independent and proficient in math classes. The calculators motivated and strongly supported certain topics such as "averages," "per cent," and above all, "decimal fractions." This is a distinct benefit.

Statistical information on test data collected in the project may be obtained by contacting the Bureau of Mathematics Education of the New York State Education Department, Albany, New York 12224.